SEMI-ANNUAL REPORT
NASA CONTRACT NAS5-31368
FOR MODIS TEAM MEMBER STEVEN W. RUNNING
ASSOC. TEAM MEMBER RAMAKRISHNA R. NEMANI
SOFTWARE ENGINEER JOSEPH GLASSY
July 15, 1996

PRE-LAUNCH TASKS PROPOSED IN OUR CONTRACT OF DECEMBER 1991

We propose, during the pre-EOS phase to: (1) develop, with other MODIS Team Members, a means of discriminating different major biome types with NDVI and other AVHRR-based data. (2) develop a simple ecosystem process model for each of these biomes, BIOME-BGC based on the logic of the current FOREST-BGC; (3) relate the seasonal trend of weekly composite NDVI to vegetation phenology and temperature limits to develop a satellite defined growing season for vegetation; and (4) define physiologically based energy to mass conversion factors for carbon and water for each biome.

Our final core at-launch product will be simplified, completely satellite driven biome specific models for ET and PSN based on this modified INDVI logic. These algorithms will be in MODISDIS before launch. We will build these biome specific satellite driven algorithms using a family of simple ecosystem process models as calibration models, collectively called BIOME-BGC, and establish coordination with an existing network of ecological study sites in order to test and validate these products. Field datasets will then be available for both BIOME-BGC development and testing, use for algorithm developments of other MODIS Team Members, and ultimately be our first test point for MODIS land vegetation products upon launch. We will use field sites from the National Science Foundation Long-Term Ecological Research network, and develop Glacier National Park as a major site for intensive validation.

OBJECTIVES:

We have defined the following near-term objectives for our MODIS contract based on the long term objectives stated above.

- Organization of an EOS ground monitoring network with collaborating U.S. and international science agencies.

Develop advanced logic for landcover classification using carbon cycle simulations from BIOME-BGC.

- Develop improved algorithms for estimating LAI and FPAR for different biome types from AVHRR data.
- Test of a generalized ecosystem process model, BIOME-BGC, for the simulation of the carbon, water and nitrogen cycles for different biomes.
- Implementation of the Global Ecological Simulation System (GESSys) to estimate continental net primary production (NPP) and ε for the globe.
- Finish formal software engineering of our MODIS products, #14 Leaf Area Index and Fraction Absorbed Photosynthetically Active Radiation, and Daily Photosynthesis - Annual Net Primary Production, #16 and 17.

The NTSG lab currently employs the following members who contribute to certain aspects of our MODIS work. :

Dr. Steven Running, Director and Professor,
Dr. Ramakrishna Nemani, Research Assoc. Professor
Dr. LLoyd Queen, Associate Professor
Dr. John Kimball, Postdoctoral Research Associate
Dr. Kathy Hibbard, Postdoctoral Research Associate
Mr. Joseph Glassy, Software Engineer
Mr. Saxon Holbrook, Computer Systems engineer
Mr. Peter Thornton, PhD student
Mr. Joe White, PhD student
Ms. Galina Churkina, PhD student
Mr. Mike White, PhD student
Mr. Geoff Poole, PhD student
Mrs. Debra Kendall, Office Manager

WORK ACCOMPLISHED:

Our core MODIS Team now consists of SWRunning, Team Member, R. Nemani, Associate Team member, and Joe M. Glassy, Software Engineer. Dr. Lloyd Queen has recently joined the faculty and our NTSG group, and is being supported by MODIS funds to develop advanced regional scale resource applications from our standard MODIS products. The following will be reports on individual activities during this reporting period.

ACTIVITIES OF SWRunning - Team Member. January 1996- July 1996,

EOS-IWG

As Chair of the EOS Land Science panel, SWR completed the draft of Chapter 7, Land Ecosystems and Hydrology for the EOS Science Plan. The text can be found on the Land Panel homepage, hosted by our lab at:

http://150.131.101.6:80/ntsg/projects/global/EOS_land/

My central objective now is to organize a logical and efficient validation plan for EOS Land science, of which the MODLAND variables are central. During the last half-year I have tried to evolve the idea of a Simple Integrated Tower Concept, which could take critical validation data for remote sensing, atmospheric corrections, surface meteorology and terrestrial ecology variables. I have given the following summary to IGOS and EOS meetings:

June 24, 1996
S. W, Running, U of MONTANA

SIMPLE INTEGRATED TOWER CONCEPT

	VARIABLE DEPENDENCIES			
	EB	ATM	BRDF	TG
COMPONENT TOWER VARIABLES				
-ENERGY BUDGET/SURFACE METEOROLOGY (EUROFLUX, FLUXNET ETC)	o	x	x	-
-ATMOSPHERIC CORRECTIONS, AEROSOLS (SHADOW-BAND RADIOMETER)	x	o	x	-
-BIDIRECTIONAL SPECTRAL RADIANCES (SUN PHOTOMETER)	x	x	o	-
-TRACE GAS FLUXES/CONCENTRATIONS (CARBON AMERICA, TRAGNET ETC)	x	x	x	o
FOOTPRINT (100KM^2) VEGETATION ANALYSIS				
-LANDCOVER	x	x	x	x
-LAI/FPAR	x	x	x	x
-NET PRIMARY PRODUCTION	x	x	x	x
-STEM AND SOIL BIOMASS	x	x	x	x

I consider this a very efficient plan for organizing one aspect of EOS validation around.

EOS-NSF/LTER

A joint proposal to NASA and the National Science Foundation was selected for start-up funding to explore sampling and instrument methodologies for measuring 3 MODIS core products, landcover, LAI and NPP over multi-hundred kilometer areas. This is a key activity in our MODLAND validation strategy, ***yet the project is only partially funded at this time.*** An organizing workshop on this project was held May 1-3, 1996 at the HJAndrews LTER in Oregon. The meeting summary follows:

> 'MOD'IS Land Science Team & 'L'ong-Term 'Ecological 'R'esearch Network 'Synthesis (MODLERS) project summary (June 21, 1996)
>
> This project brings together 14 Long-Term Ecological Research (LTER) Network sites and NASA's MODIS Land (MODLAND) Science Team for the purpose of locally validating Earth Observation System-era global data sets. Using several standardized methods that incorporate extensive ground data sets, ecosystem models, and remotely-sensed imagery, each LTER site is developing local maps of landcover class, leaf area index, and aboveground

net primary productivity for a 100 km2 area at a grain size of 25 m. A nested, hierarchical ground-based sampling scheme will help establish error bounds on the variable estimates. A number of different strategies are being used to spatially aggregate the fine-grain site maps to a coarse grain (1 km) so that they can be compared to coincident portions of global maps of the same three biosphere variables developed by the MODLAND Science Team. This coordinated, multi-site grain-size aggregation exercise presents us with an opportunity to grapple with one of the most vexing current problems in ecology: effects of scaling from a fine grain to a coarse grain on estimates of important biosphere variables. We are using several spatially-explicit, geostatistical methods to address this issue, with the intent of determining how best to maintain crucial information among grain sizes. Additionally, we are characterizing similarities and differences among the multiple sites and biomes and between the MODLAND maps and the site maps at each grain size, in terms of the three mapped biosphere variables. For more information visit our web site at

http://atlantic.evsc.virginia.edu/~jhp7e/modlers/

MODLERS Project bullets:

* Structured into 7 working groups--1) technical remote sensing, 2) LAI/NPP field measurements, 3) land cover mapping, 4) spatial aggregation, 5) cross-site comparison, 6) data management, and 7) communications

* Technical remote sensing is the resource groups for spectral vegetation indices, atmospheric corrections, etc.

* LAI/NPP measurements is describing methods from literature to help determine best methods for estimates across the network, and for designing sampling strategy

* land cover mapping responsible for defining land cover schemes and translations among schemes, and for definition of accuracy assessment standards

* spatial aggregation will conduct standard aggregation of all 25 m data layers to 1 km

* cross-site is for comparing models and methods across sites, for comparing sites at all aggregation levels, and for integrating results with MODLAND

* data management is to facilitate ready availability of data sets needed by

MODLERS and, ultimately, outside users

* communications is where our web-page activity is

Most important issues were addressed and solutions derived at the workshop. We are preparing written material for peer-review, and for submission as a special issue to journal, By end of calendar year we plan to have several ms. ready for submission, will have some results on LCC map aggregation, and will have existing LAI/NPP data organized and ready to use,

NSF - National Center for Ecological Analysis and Synthesis

SWR was selected for the Scientific Advisory Board of the newly NSF funded NCEAS, which met in February 1996. This center can play a significant role in organizing terrestrial research data for EOS science, and should play a useful role in the EOS Validation Plan. The homepage is at:

http://www.ceas.ucsb.edu/

Global Climate and Terrestrial Observing Systems (GCOS/GTOS)

SWR has been appointed to the Terrestrial Observation Panel for Climate, TOPC, planning a joint Global Climate and Global Terrestrial Observing System (GCOS-GTOS) Terrestrial Observing System. SWR attended an IGOS (Integrated Global Observing System) meeting in June 1996 to plan a strategy for synergism amongst the Global Climate, Terrestrial and Ocean Observing Systems.

VEMAP - Vegetation ecosystem modeling and analysis project

VEMAP is a project to intercompare leading biogeography and biogeochemistry models in the US for global change and EOS research programs. VEMAP has a homepage at:

http://www.cgd.ucar.edu:80/vemap/

The BIOME-BGC model that is part of our MODIS algorithm development for our NPP product is one of the three biogeochemistry models being tested. The other two models are from the Moore and Schimel EOS/IDS teams. The first VEMAP paper has been published in the December 1995 issue of Global Biogeochemical Cycles, and is attached.

IGBP Biospheric Aspects of the Hydrologic Cycle (BAHC)

As a member of the Science Steering Committee for BAHC, SWR has been involved with writing the Science Plan for BAHC Focus 1, and planning the science

agenda for 5 years now. SWR is working with Drs Dennis Baldocchi and Ricardo Valentini concerned with organizing a global network of $C0_2$ and H_20 flux towers for continuous validation of MODLAND vegetation flux products, This network called FLUXNET, is based on the La Thuile, Italy workshop, and was published in Global Change Biology, in June 1996, reprint attached. FLUXNET is a precursor to the EOS Simple Tower Concept I am working on. I met in January and April, 1996 for BAHC meetings.

Carbon-America

A new activity is being organized to design an atmospheric measurement system for the continental US as a validation source for Earth Systems Models and EOS measurements. This activity is being discussed on the Internet, being called Carbon-America, and is led by Dr. Pieter Tans from NOAA in Boulder, CO. This is a related activity to tower networks that in my mind needs to be integrated into a larger single network plan, which I will work on in the coming months,

PIK NPP Workshop

The IGBP-GAIM project is running a global NPP model intercomparisons at the Potsdam Institute for Climate change in Potsdam, Germany. This activity is the most organized effort in the world to determine best NPP analysis for validating the MODLAND NPP product. Steve Prince is leading an activity to build a global database of published NPP measurements, Galina Churkina and SWR are writing a paper analyzing the water balance control logic of the PIK-NPP models, and a second paper on the multiple environemental controls of NPP expressed in our BIOME-BGC model.

GAP Analysis Project

The GAP analysis project is a US National Biological Service funded project to map wildlife habitat in each state using high resolution satellite imagery. Their homepage is at:

http://www.gap.uidaho.edu/gap/

I am working with the national GAP office about sharing their database with the MODLAND team to use as a validation source for our Landcover algorithm. Details of this agreement are being developed.

NASA EOS MEETINGS ATTENDED (SWR)

EOS-SEC Meetings January, February, March and May 1996,
IGBP 1st International Congress Germany, April 1996
EOS Test Site Meeting March, 1996
EOS Hydrology Proposal Review panel April 1996
EOS Validation Plan Meeting May, 1996

EOS IWG Meeting May, 1996
MODIS SWAMP Review May, 1996
IGOS Meeting June 1996

ACTIVITIES OF R. NEMANI - MODLAND

WORK ACCOMPLISHED

* Generated soil brightness values using AVHRR Pathfinder data:

Using red and nir reflectance from AVHRR pathfinder data, we tested the global soil line concept. In general the soil line concept holds good globally, except in shrublands and desert areas. With the help of this concept, we divided the global soils into three groups: dark, medium and bright. For each category we estimated a soil NDVI.

* Compiled leaf spectra for over 150 plant species and generated spectral responses for AVHRR bands 1 &2.
* generated relationships between LAI/FPAR and NDVI for Pathfinder AVHRR data using Myneni's 3-D RT model for six biome types (Grass, Shrub, Savana, leaf forest, needle forest and broadleaf crops).
* Monthly maps of LAI/FPAR were produced for 10 years (1 982-1991).
*Analyzed the inter-annual variability in NDVI and surface temperature using Pathfinder datasets.

WORK IN PROGRESS

* Identification of green-up and senescence phases of global vegetation using AVHRR data
* Estimation of ground cover for the 8 km Pathfinder data using 1 km Pathfinder data.
* Compiling additional leaf spectra and generating responses for MODIS wavelength bands
* Analysis of monthly fields of LAI/FPAR derived from Pathfinder data.
* Deriving the six biome types globally using 1 km AVHRR data.
* Simulation of canopy reflectance in the MIR wavelengths over conifer forests.

MEETINGS ATTENDED

May 1996: MODIS Science meeting, Washington, D.C
MODIS ATBD review, Washington, D.C
BOREAS Science meeting, Toronto,

ACTIVITIES OF J.M. GLASSY. UM SCF MODIS SOFTWARE ENGINEER

OBJECTIVES

1) During this period, priority was given to software development in preparation for the Version 1.0 software delivery of both the MOD I 5 and MOD17 AM-1 At-Launch algorithms. Areas of emphasis for the MOD I 7 algorithm include development and test of the DAO climatology temporal pre-processor, and refinement of the biome properties lookup table (BPLUT). Areas of emphasis for the MOD I 5 algorithm include integration and test of the latest ECS metadata handling codes into the core algorithm. The V.1.0 deliveries are slated for the September 1996 timeframe.
2) Incremental improvements in the MODIS Univ. Of Montana SCF MODIS Compute Ring (MCR) are underway, highlighted by the installation of the next major compute ring element, an IBM RS/6000 Model J-30 Symmetric Multiprocessor Computer with 8 CPUs.. and 1G of physical memory, 128G of attached MTI RAID 0/3/5 fixed disk store, and the network integrated Exabyte 440 8mm (40 cartridge) tape robot.
3) The next phase of the planned network upgrade to the Univ. of Montana MODIS Compute Ring is also well underway, with the arrival of the CISCO Catylst 5000 C5K intelligent switch.

WORK ACCOMPLISHED

1) MOD15 (FPAR, LAI) Version 1 Software

During this the period, the main focus of MOD15 (FPAR, LAI) code development continues to be integrating the new ECS PVL/OVL based metadata procedures into the code. A number of on-going software engineering (non-science) related issues were also addressed, including use of the new Lbin (Level 2G gridding) library, making the transition to the new ECS SDPTK version 5.1 toolkit and the HDF version 4.0r2 release science software library. The prototype EOS-HDF library was also downloaded and successfully built on our RS/6000 AIX 4.1.4 platform. The EOS-HDF documentation is under review for Implications requiring re-design of our MODIS Land level 4 algorithms. The MOD I 5 SCF Algorithm Implementation Plan (AIP) was also updated to reflect changes made during this period to Q/A and input reflectance structure, Internal software source code documentation elements (e.g. required ECS prologs) were also inspected for all MOD I 5 Pre-beta source codes as a result of the Pre-beta code review, with the majority of recommended changes in place now.

2) MOD17 (PSN, NPP) Version 1 Software

The pre-beta and Version 1.0 generation of the MOD17 (PSN, NPP) algorithm are currently under co-development, with deliveries rescheduled to the September 1996 timeframe. Structural revisions of the MOD17 biome properties lookup table (BPLUT) containing the core algorithm equation coefficients necessitated several rounds of code revisions. Emphasis during this period has been given to ECS metadata integration via the new SDPTK v. 5.1 library and SDST code templates, as well as to refining our V.1.0 Q/A logic. The global surface daily climatology inputs provided by the Data Assimilation Office (DAO) modified NMC have also required considerable on-going integration effort since these must be both temporally and spatially aggregated prior to ingest by our models. Updated MOD17 (PSN, NPP) Data Flow Diagrams have been developed that capture minor recent changes to the MOD I 7 logic (see attached), and the MOD17 SCF

Algorithm Implementation Plan (AIP) was updated to reflect a number of minor implementation changes to the PSN algorithm.

The MOD17 PSN, NPP algorithm suite consists of (3) separate executable elements:

clim_psn climatology pre-processor to temporally aggregate the 3-hour timestep DAO global surface assimilated climate data (at 2.5 deg latitude by 2,0 longitude) to the daily timestep required by MOD I 7 “psn_npp” executable.

psn_npp . ..core MOD17 algorithm that fires daily and accumulates intermediate PSN and NPP estimates, which are output as 8-day and annual composites (PSN and NPP respectively) on the L2G/L3 sinusoidal (analysis) grid,

aggr_psn . ..post-processor to spatially resample the outputs on the L2G analysis grid to the coarse climate model (equal-angle) geographic grid.

Highest development priority is given to the clim_psn module, since the climatology data it produces represents a critical-path input to the core algorithm, psn_npp. Next highest priority is given to the psn_npp module.

3) Software Engineering Tools/Methods

New ancillary software tools developed during this period include a generic ECS software prolog extraction software system (“promerge”), consisting of a series of integrated shell scripts and a binary executable. This software automates the extraction of ECS source code prolog elements at either the file context level or the prolog metadata element level, for ingest into the local SCF relational database environment (Recital on IBM AIX, Visual FoxPRO on PC platforms),

Several new MODIS-Univ, Montana (MUM) Application Program Interface (API) client utilities have been developed or enhanced during this period, including:

rawtohdf . ..utility to ingest raw binary image files into the NCSA HDF SDS format

hdftoraw . ..utility to extract NCSA HDF SDS data images into raw binary files

genhdf utility to produce new HDF files with complete user-specified attribute descriptions

hdfdict . ..utility to build a complete HDF metadata (dictionary) summary report, for all global, SDS, and dimension context attributes from a given HDF volume. This utility will be used to organize and catalog a variety of HDF datasets, including the MOD15, MOD17 inputs and outputs and the DAO assimilated climatology data sets.

Lastly, a series of CDOC input batch scripts have been developed for generating routine sets of annotated MODIS source code logic (tree) diagrams, variable cross-reference reports.

4) Science Data Development

A full 10 year sequence of the NASA AVHRR Pathfinder 8 KM global dataset was brought

onsite and fully reprocessed to yield monthly averages of key variables including NDVI, RED, NIR, and as well as surface temperature, Additionally, the NASA AVHRR Pathfinder 1 KM North American Continent 10-day dataset ordered from the EROS Data Center (EDC) DAAC was processed to generate the same variables. This NASA Pathfinder dataset continues to serve as a globally complete reflectance dataset for MOD15 and MOD I 7 algorithm development until launch of the AM-1 platform.

For the MOD I 7 PSN, NPP algorithm development effort, a backup test global surface climatology has been assembled from UCAR/NCAR sources, This spatially distributed climatology dataset is a daily timestep climatology comprised of (4) fields: near surface air-temperature (deg C), incident shortwave solar radiation (W/m^2) , relative humidity (%). A daily accumulated precipitation field (mm units) is also included for this dataset, for MOD16 ET and surface resistance algorithm development. The spatial resolution for the climatology data is 1 degree (latitude) by 1 degree longitude.

5) SCF Compute Facility Development

During this period, the second complement of 64G RAID Level 3/5 fixed disk store has been implemented on site, using MTI RAID controllers mounted in a 19“ vertical rack. This disk increment brings our MODIS RAID disk storage capacity to 128G, with another 128G of RAID 0/3/5 planned to be added by January, 1997. In addition, a high performance Digital Equipment Corporation Storage-Works 32G RAID subsystem was brought on-site for real-time testing and evaluation,

Several new compute elements of the MODIS Compute Ring (MCR) arrived during this period and will soon be configured on-site, including: an IBM RS/6000 Symmetric Multi processing (SMP) Model J-30 high performance workstation, an additional 64G of MTI RAID 0/3/5 fixed disk store, a Trimm 19“ air-cooled component rack, and a CISCO Catylst 5000 C5K network intelligent switch which will enable the ATM interface to EDC.

MEETINGS ATTENDED

May MODIS Science Team Meeting, GSFC,
July 11-12, 1996: MODLAND-SDST Meeting held at Goddard Space Flight Center.

ON-GOING ACTIVITIES

* The priority development effort remains to get the MOD I 7 algorithm suite ready for the VI software delivery slated for early fall, 1996.

* The MODIS-Univ. Of Montana (MUM) Application Program interface multi-platform (Unix/AIX, NT, Linux) library is being enhanced to include a more complete and robust interface to the NCSA HDF SDS data interface, focusing on attribute management capabilities.

* A new room in the University of Montana Science Complex (SC 448) has recently been dedicated by the School of Forestry to house the MODIS Compute Ring

(MCR) hardware facility. Work has begun to retrofit the room to the needs of a mid-size compute facility, with all equipment moves scheduled to be completed by the early fall, 1996.

* An agreement has been reached between our NTSG SCF lab and Digital Equipment Corporation for DEC to provide us with a no-cost DEC Model 4100 SMP evaulation unit. This high performance symmetric processing compute server is slated for installation in the fall 1996 timeframe, and will be evaluated under standard our MODIS SCF algorithm compute loads.

Activities of Dr. LLoyd Queen:

1996 saw expanded development of an applications program to apply, test, and distribute several of the MODIS prototype terrestrial applications products. The five major accomplishments of this activity to date are:

1) Identified and developed collaborations with a dozen applications partners,
2) Increased awareness of the potential of planned products to natural resource planners and managers in the region through education and training programs,
3) Solicited and received six complementary research projects,
4) Presented/ four papers describing the work, and
5) Recruited and supported six new graduate students and research specialists.

Projects are in place or under development with public as well as private partners; including the USDA Forest Service Region 1 Office, the USDA Forest Service Intermountain Fire Sciences Laboratory, the Nature Conservancy, the Rocky Mountain Elk Foundation, the Natural Resources Information System of the Montana State Library System (Governor's Task Force on Drought Monitoring), the National Geophysical Data Center, and several universities, including Montana State University, North and South Dakota State Universities, the Universities of North and South Dakota, Wyoming, Idaho, and the South Dakota School of Mines. These collaborations have leveraged an additional $1,029,573 that is being shared with partners interested in the use of these advanced science products. A small portion of that support has been used to design and test alternative compute environments for the planned algorithms; including distributed computing strategies.

These projects embrace a range of natural resource topics; including the application of image products to landcover change detection and monitoring, assessment of wildlife habitat relationships, hydrologic characterization at large space scales, and real-time assessment of emissions from biomass burning, The specific algorithms being applied are surface resistance, leaf area index, productivity, and several indices of drought, fire, and vegetation status. Each project will use pathfinder data to implement and test product algorithms, with the goal of ramping up to a near-real-time applications and distribution environment at launch of AM-1 in 1998. This rapid delivery of image products is of special interest to our research joint venture agreement with the Forest Service's Intermountain Fire Sciences Laboratory. A 3-year project concept, shown in Figure 1, will involve

integration of multiple image products into a model designed to estimate emissions of trace gases and particulate from biomass fires at continental scales in rapid mode. The role of the Internet as a data and metadata distribution vehicle is imbedded in most of the research programs that are underway. As an established node on the National Spatial Data Infrastructure, the Montana State Library (NRIS Office) is a key partner in developing strategies to provide public access to applications products for the northern Rocky Mountain region.

Papers Presented:

"Empowering the Public to Access and Apply Advanced Terrestrial Science Products from EOS." L. Queen, Montana GIS Users Conference, Missoula, MT, 1996.

"Mapping Potential of Remote Sensing Imagery for Site-Specific Crop Management." G. Nielsen, D. Long, and L. Queen, SPIE Optical Engineering Society Meetings, Denver, CO, 1996.

"Terrestrial Remote Sensing Products Planned for EOS/MODIS." L. Queen. Public Access Resource Center user Group Meetings, Minneapolis, MN, and Missoula, MT, 1996.

"Potential for EOS/MODIS Remote Sensor Products for Modern Soil Survey and Assessment." G. Nielsen and L. Queen, Rocky Montain/Great Plains Soil Survey Meetings, Bozeman, MT, 1996.

Leveraged Sponsorship.

"Application of MODIS Airborne Simulator, AVHRR, and DMSP for Characterization of Biomass Burning." USDA Forest Service, lntermountain Fire Sciences Laboratory. $25,000. L. Queen, S. Running, and J. Plummer.

"Image Restoration of Multi-date Landsat TM Imagery." Montana Space Grant Consortium, Montana State University EPSCOR Program, Bozeman, MT. $38,649. L. Queen.

"Prototype implementation of a Federated EOSDIS Partner for the Northern Rockies. NASA. $310,257 G. Seielstad, D Helder, P. Johnson, J. Korol, G. Nielsen, W. Perrizo, S. Running, L. Queen, P Smith.

"Forest Change Detection and Monitoring: Integration of Ground, Aerial, and Satellite Survey s." McIntire-Stennis Cooperative Forestry Research Program, Montana Forest and Conservation and Experiment Station. $114,957. L. Queen.

"A Public Access Resource Center Empowering the General Public to Use EOSDIS: Phase II: PARC Implementation." NASA, $514,710. G. Seielstad, S. Farwell, J. Korol, P. McClurg, G. Nielsen, L. Osborne, W. Perrizo, L. Queen.

"Compute Server for Visualization and Rendering." Request to Silicon Graphics for Indigo2 Computer Workstation. $26,000. L. Queen.

Participating Students and Research Staff:

James Plummer, PhD student. School of Forestry, University of Montana.

Brad Villnow, PhD student, School of Forestry, University of Montana.

Craig Thompson, MS student. School of Forestry, University of Montana.

Erica Hoffa, MS student. School of Forestry, University of Montana.

Chris Winne, Post-Doctoral Research Assistant. Wildlife Spatial Analysis Laboratory, Division of Biological Sciences, University of Montana.

Michael Sweet, Research Specialist, School of Forestry, University of Montana,

PUBLICATIONS:

Nemani, R., S.W. Running, R. PieIke and T. Chase. 1996. Global vegetation cover changes from coarse resolution satellite data. J. Geophys. Res., 101(D3): 7157-7162.

Chase, T., R. PieIke, T. Kittel, R. Nemani and S. Running. 1996. Sensitivity of a general circulation model to global changes in leaf area index, J. Geophys. Res., 101(D3): 7393-7408.

Baldocchi, D., R. Valentine, S. Running, W. Oechel, and R. Dahlman. 1996. Strategies for measuring and modeling CO2 and water vapor fluxes over terrestrial ecosystems. Global Change Biology 2:159-168

Nielson, R. P. and S. W. Running. 1996, Global dynamic vegetation modeling: coupling biogeochemistry and biogeography models. Global Biogeochemical Cycles (in press)

Kremer, R. G., E. R. Hunt, Jr., S. W. Running, and J C. CoughIan. 1996. Simulating vegetational and hydrologic responses to natural climatic variation and GCM-predicted climatic change in a semi-arid ecosystem in Washington, U.S.A. Journal of Arid Environments (in press).

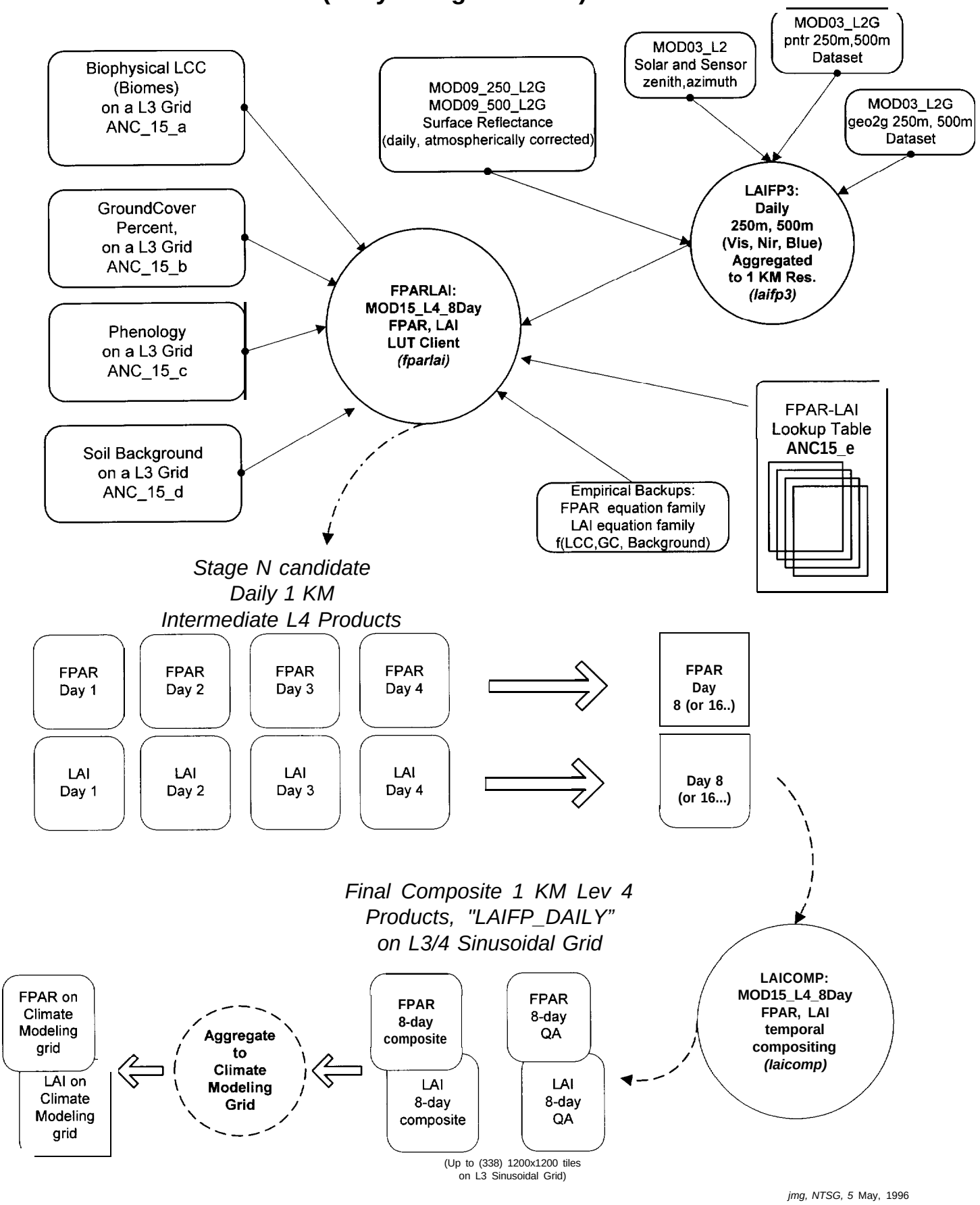
Nemani, R., and S. W. Running, 1996. Land cover characterization using multi-temporal red, nir and thermal-ir AVHRR data Ecological Applications (in press),

Nemani, R.R. and S.W. Running. 1996, Implementation of a hierarchical global vegetation classification in global ecosystem models. J. Veg. Science (in press).

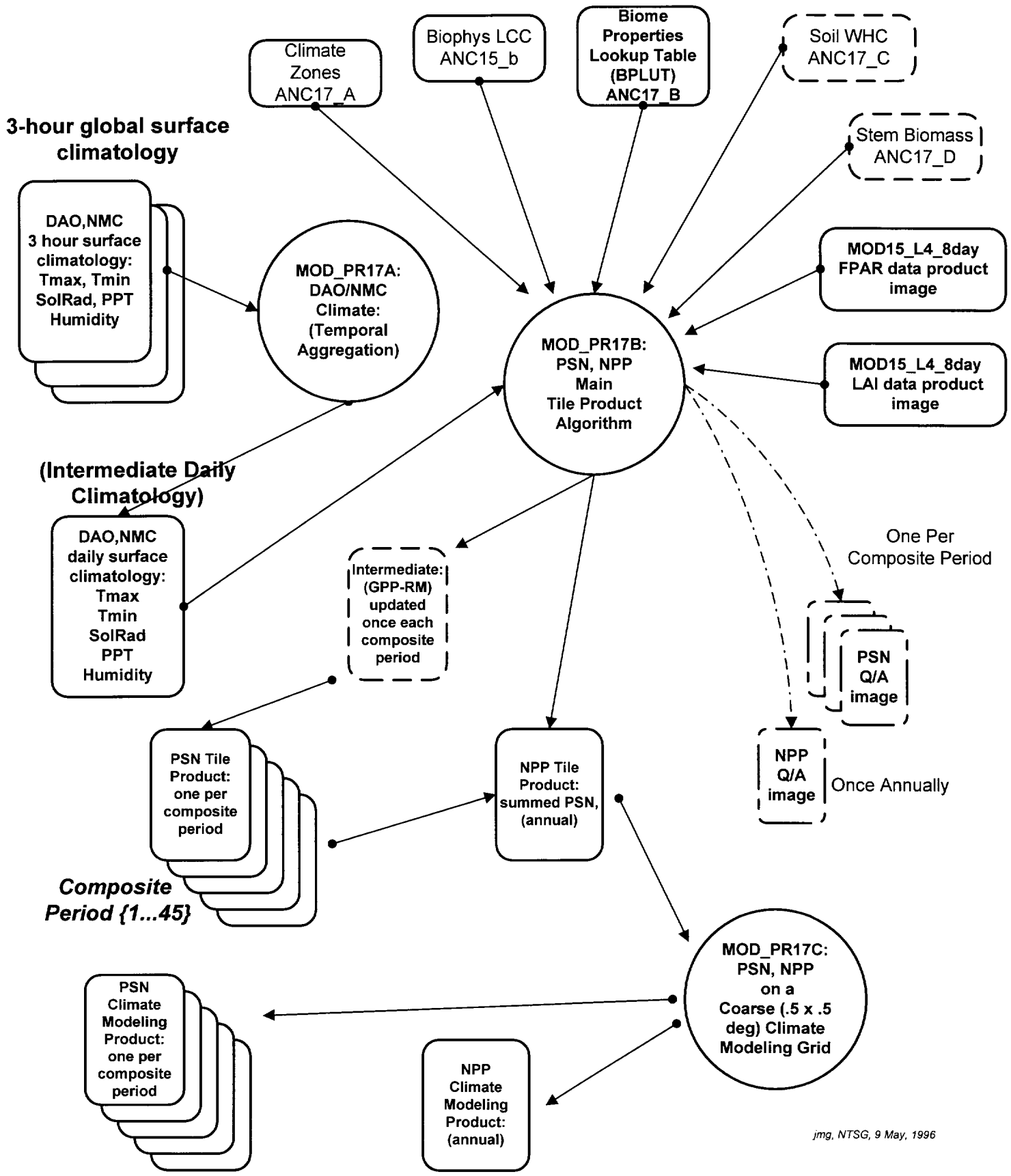
Hunt, E.R. , S. C. Piper, R. Nemani, C. D. Keeling, R. D. Otto, and S. W. Running, 1996. Global net carbon exchange and intra-annual atmospheric CO2 concentrations predicted by an ecosystem process model and 3-d atmospheric transport model. Global Biogeochemcial Cycles. (In press)

Myneni, R. B., R.R. Nemani and S.W. Running, 1996, Algorithms for deriving land cover and LAI/FPAR based on radiative transfer models. IEEE Trans. Geoscience and Remote Sensing (submitted).

MODIS MOD15 (FPAR,LAI)
Data Flow Diagram
(Daily Firing Scenario)



MODIS MOD17 (PSN, NPP)
Data Flow Diagram
(daily firing scenario)



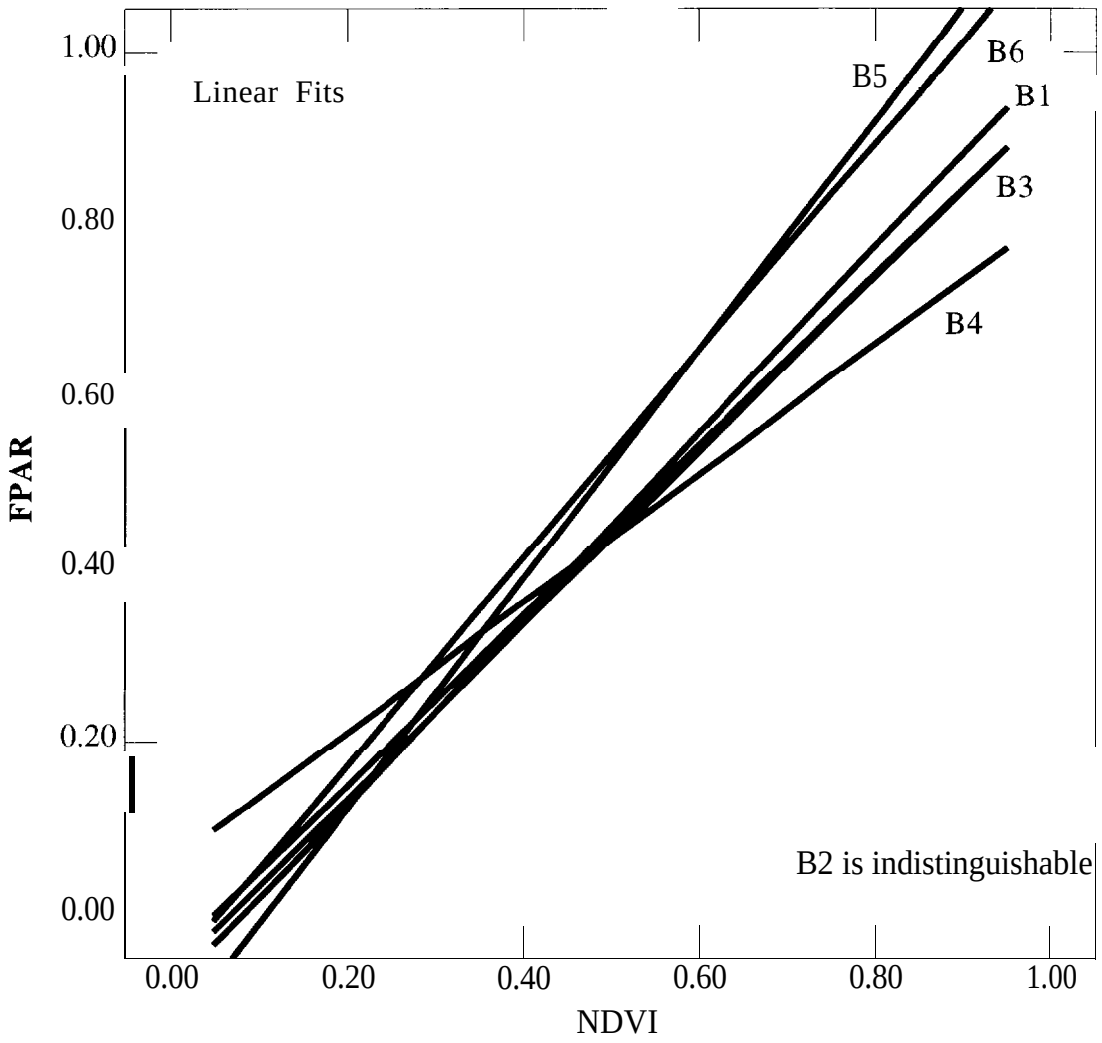


Figure 3. Regression fits to all data from the sensitivity analysis. The notation is explained in the legend of Figure 2.

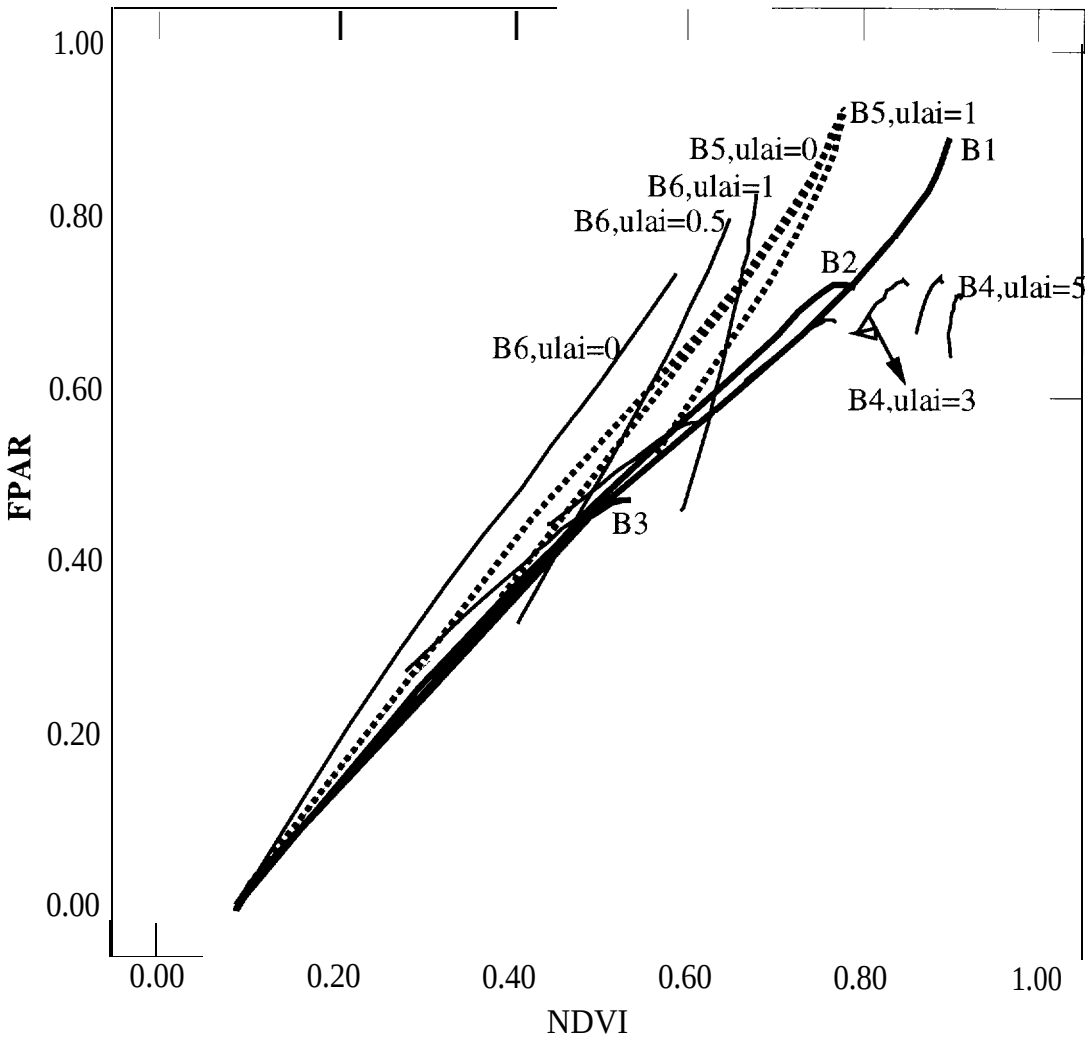
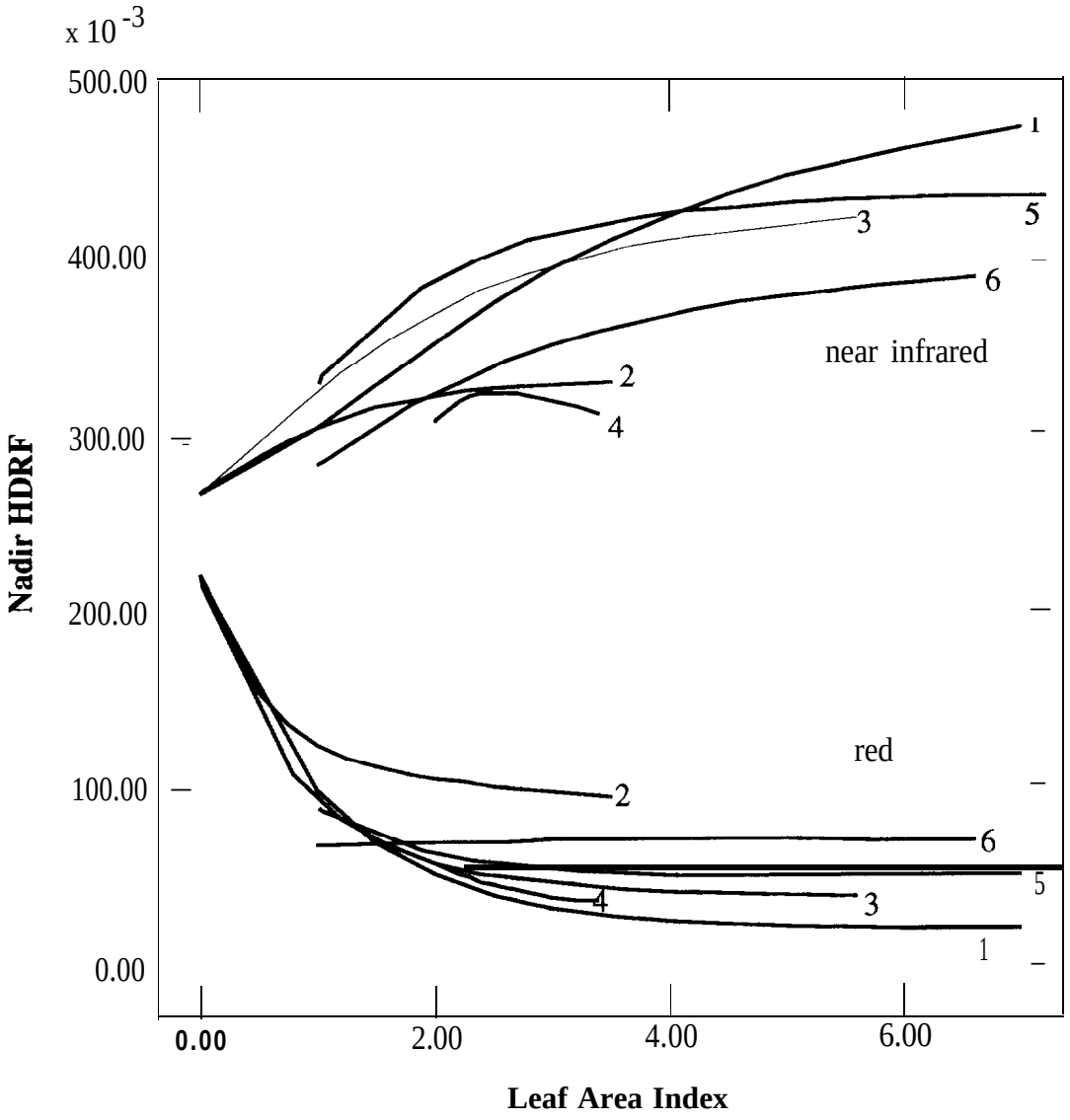
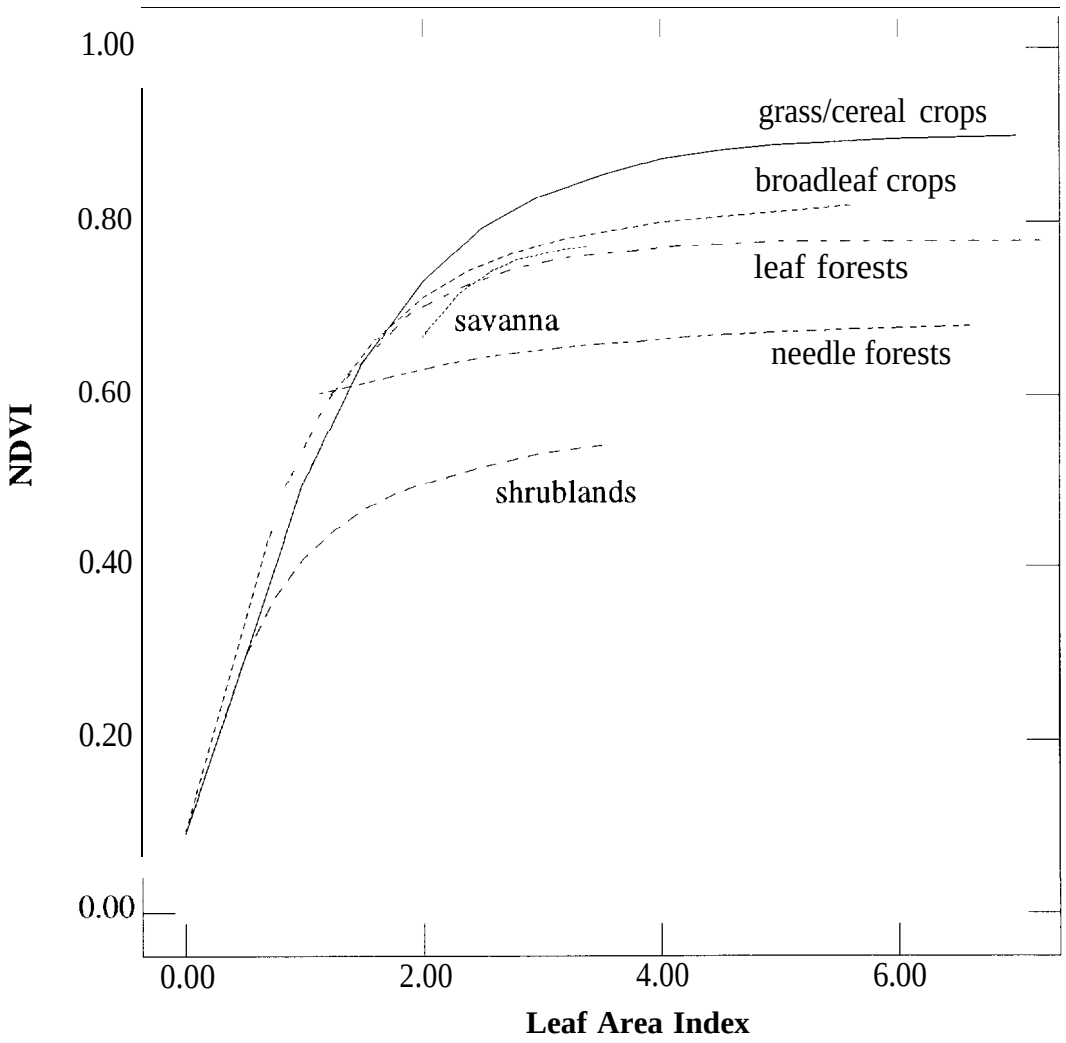


Figure 2. The relationships between FPAR and at-surface NDVI in the base case simulation. The notation-is as follows: “Bn” refers to Biome n, where n = 1 (cereal crops or grasses), n = 2 (shrublands), n = 3 (broadleaf crops), n = 4 (savannas), n = 5 (broadleaf forests) and n = 6 (conferous forests). The abbreviation “ulai” refers to understorey leaf area index.


x 10 -3
500.00
400.00
300.00
200.00
100.00
0.00
Nadir HDRF
near infrared
red
1
2
3
4
5
6
0.00
2.00
4.00
6.00
Leaf Area Index


1.00
0.80
0.60
0.40
0.20
0.00
NDVI
grass/cereal crops
broadleaf crops
leaf forests
savanna
needle forests
shrublands
0.00
2.00
4.00
6.00
Leaf Area Index